170110

K. 7
7/8/88

INTERIM REPORT
OF
VAPOR EXTRACTION PILOT TEST

JULY 8, 1988

PREPARED BY:

ENVIRONMENTAL RESOURCES MANAGEMENT-NORTH CENTRAL, INC.
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INTRODUCTION

Vapor extraction is a process used to remove volatile organics from contaminated soils. The process works by withdrawing volatile contaminants from soil, in-situ. A subsurface vacuum is propagated from extraction wells or an extraction trench which causes vapors to migrate to the extraction wells or trench. The vapors are brought from the wells or trench to the surface where they are vented and destroyed by on-site catalytic incineration (except during the pilot test).

Terra Vac, Inc. is currently conducting a soil vapor extraction pilot test at the Envirochem site (ECC), near Zionsville, IN. Data from the pilot test is to be used to determine the feasibility and the cost of a full-scale vapor extraction system at the site.

INSTALLATION OF THE PILOT TEST VAPOR EXTRACTION SYSTEM

Mobilization of Terra Vac, Inc. to the site began on May 31, 1988. The installation operations of a vapor extraction pilot test system started on June 7. Two 40-foot trenches (HEW 1 and HEW 2, See Figure 1-1) were excavated to a depth of 9 feet. At this depth, a small amount of water (<2 gals) was encountered in the east trench (HEW-1). A dark brown separate phase was noted on the water's surface in de minimus quantity (photograph will be forwarded).

Both trenches were backfilled with pea gravel to the 8-foot level. A four-inch PVC screen was installed along the entire length of each trench. A four-inch PVC riser pipe was connected at each end of the screen and extended above the top of the trench. The trenches were then backfilled with pea gravel to the 5-foot level. A second layer of PVC screen was placed at the 5-

foot depth. The trenches were then backfilled with pea gravel to the 3-foot level. A six-inch layer of wetted-powdered bentonite seal was placed followed by grout to grade level.

The lower pipe (at the 8-foot depth) was installed to collect any ground water that collected in the trench. This lower pipe was not connected to the vapor extraction system. Although no ground water has accumulated since installation (due to drought conditions) we intend to attempt to collect representative samples of ground water for characterization with respect to ultimate discharge to the City of Indianapolis.

The upper pipe is used in the vapor extraction system process. The riser pipe is connected to a pipe at the surface. This pipe leads to the water extraction system, then to the pump where the vapors are vented. Emission controls were not used during the pilot test due to the low emission levels in the vented soil vapors as determined by ambient monitoring.[1]

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[1] Since starting up, the system has been continually monitored by Terra Vac, Inc. using an on-site gas chromatograph. Vapor samples are collected at several points within the flowline and at the exhaust stack. Vapor samples were analyzed approximately every two hours during startup. The sampling frequency was reduced later in the test to approximately once/day. Data from the piezometers were also obtained for use in calculating the zone of influence.

During the system's operation, the site ambient air was monitored by ERM using a Photovac tip. The monitoring points (AM 1-1 through AM 2-9) enclosed the pilot test area as shown in Figure 1-2. Initially, the points were monitored on an hourly basis. Values up to 2.5 ppm above background were noted along the outer circumference. The concentrations measured along the outer circumference were well below the 5 ppm action level confirming that no potential health hazards to neighboring residents existed during the pilot test.

Ten piezometer wells were installed to monitor the system (Figure 1-1). Four of the piezometers (VM-1 to VM-4) were drilled and installed by Engineering and Testing Services, Inc. (ETS) of Indianapolis. ETS also drilled and installed a vertical extraction well (VE-1) which Terra Vac, Inc. intends to use to compare the efficiency of vertical to horizontal collection. The additional six piezometers (KVM-5 to KVM-10) were drilled and installed by Terra Vac, Inc. utilizing a hand drill.

Soil samples were collected during all phases of the trenching and drilling operations. A headspace analysis was performed on each soil sample utilizing an on-site gas chromatograph. Headspace concentrations ranged from 100 - 400 ppm. The main compounds identified included: DCA, DCE, TCE, toluene, PCE, and xylene. During the trenching and drilling operations, the work area was constantly monitored for ambient organic vapors by ERM-North Central personnel, utilizing a Photovac tip. Values obtained did not exceed the 5.0 ppm action level negotiated with IDEM for personnel safety protection upgrading.

PILOT TEST OPERATION

Development of the vapor extraction system started on June 13, 1988. The system has since operated continuously, except during brief shut-down periods for maintenance.

PERFORMANCE ANALYSIS

Based on data provided by Mike Disabato of Terra Vac on June 24, 1988, (a copy of which is attached as Appendix A) ERM-North Central has calculated the performance score of the vapor extraction technology using the results of the pilot test being conducted at ECC. The calculations presented below follow the procedure described in our technical memorandum "Site Specific Evaluation of Vapor Extraction Application"[2] and are based upon data collected through June 17, 1988.

Horizontal Extraction Well No. 2

Trench dimensions: 40 ft long x 1 foot wide x 9 feet deep.

Soil total VOCs concentration: range from 100 to 400 ppm.

Zone of influence: 15 feet (30 feet wide).

Extraction rate at time of development: 57 pounds per day.

Utilizing the above information, the soil mass affected by the vapor extraction pilot test is approximately 40 ft x 30 ft x 9 ft, which equals 400 cubic yards. Assuming 1.5 tons per cubic yard, this equates to 1.2×10^6 pounds of soil. Based on the RI data, 400 ppm was conservatively assumed as the initial VOCs concentration for the entire soil mass. This is equivalent to 480 pounds of VOCs in the affected soil mass. Therefore, with an extraction rate of 57 pounds per day when the trench was developed, the initial contaminant mass extraction rate is 11.9 percent per day.

The vapor extraction technology performance is rated as follows, utilizing Table 2 in the previously referenced "Site Specific Evaluation of Vapor Extraction":

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[2] Letter from ERM to Karen Vendl, USEPA, April 27, 1988

- The zone of influence (weighting factor of 3) receives a score of 60, since the materials excavated are predominantly clays and the zone of influence is 15 feet.

- The initial contaminant mass extraction rate (weighting factor of 2) receives a score of 80, since the removal is greater than 5 percent of the total concentration within the mass contained in the zone of influence.

- Finally, to be conservative, it is assumed that emission controls (weighting factor of 1) will be required during initial remediation, resulting in a score of 60.

These scores are then multiplied by their weighting factors, added, and divided by 6 to calculate an average performance score of 66.67 for Horizontal Extraction Well No. 2. If no emission controls are required during full-scale operation, the resultant performance score would be 70.

Horizontal Extraction Well No. 1

Similar calculations were carried out for Horizontal Extraction Well No. 1 for the same time period. The pertinent data are shown below:

Trench dimensions: 40 ft long x 1 ft wide x 9 ft deep.

Soil total VOCs concentration: ranged from 10 to 20 ppm.

Zone of Influence: 15 feet (30 feet wide).

Extraction rate at the time of development: 15 pounds per day.

Calculated similarly to Horizontal Extraction Well No. 2, 200 ppm was conservatively assumed for this area as the average concentration (based on the RI data). The initial VOC mass within the affected soil is 200 pounds, and the initial contaminant mass extraction rate equals six percent. Therefore, utilizing Table 2 to score the performance of Horizontal Extraction Well No. 1, the zone of influence receives a score of 60, the initial contaminant mass extraction rate receives a score of 80, and the emission controls receive a score of 60 with controls during initial remediation and a score of 80 with no controls. The resultant performance scores are 66.67 and 70, with and without controls, respectively.

Referring to Figure 1 of the previously referenced "Site Specific Evaluation for Vapor Extraction Application," a score of 60 or greater is necessary to implement vapor extraction and to proceed with the preliminary design and engineering. Based on the initial results from the pilot test, the performance of the system exceeds the criteria for a recommendation to the design phase.

VAPOR EXTRACTION PILOT TEST EXTENSION

The pilot test has been extended for an additional 4 weeks, starting July 1, 1988. The pilot test was extended to better define the expected duration of operation of a full-scale soil vapor extraction system and the associated cost.

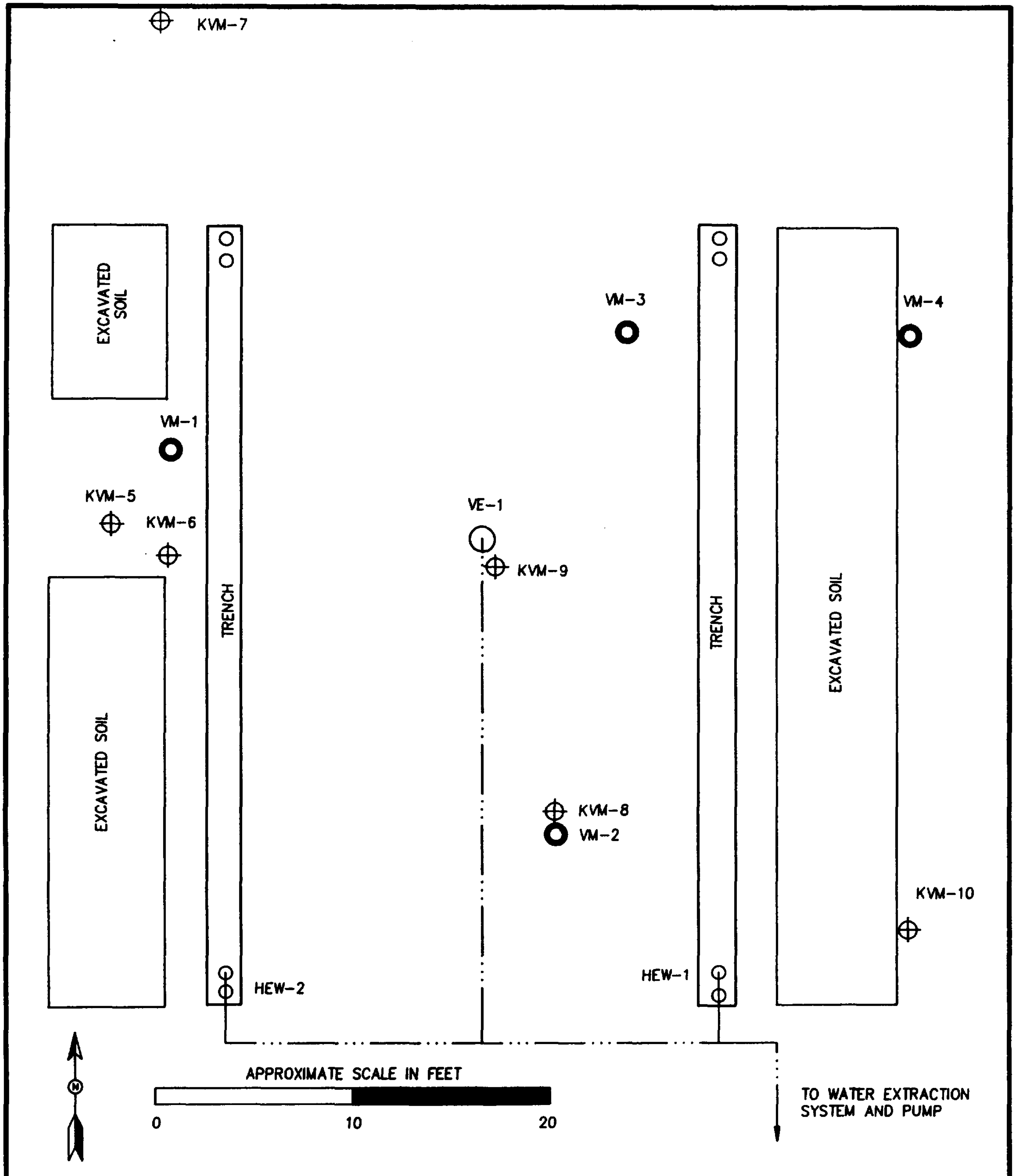
Samples will be collected by ETS 3 times/wk during the extended test period (a total of 12 additional samples) and sent to Terra Vac for GC analysis. ETS will continue to perform ambient site monitoring during sampling. ERM will visit the site once each week to confirm that the sampling and maintenance duties are being performed by ETS. ERM will also confirm that the vapor emissions remain below the action level. The on-site trailer will remain for the extended test.

SUMMARY

What is the necessary reduction? Never been defined

A vapor extraction pilot test has been conducted by Terra Vac at the ECC site. Based on data received and the criteria previously set, the vapor extraction system is successful in achieving the necessary reduction in VOC concentrations at the ECC site. The pilot test has been extended for an additional four week period. The benefits of the longer test and the associated expanded data base include:

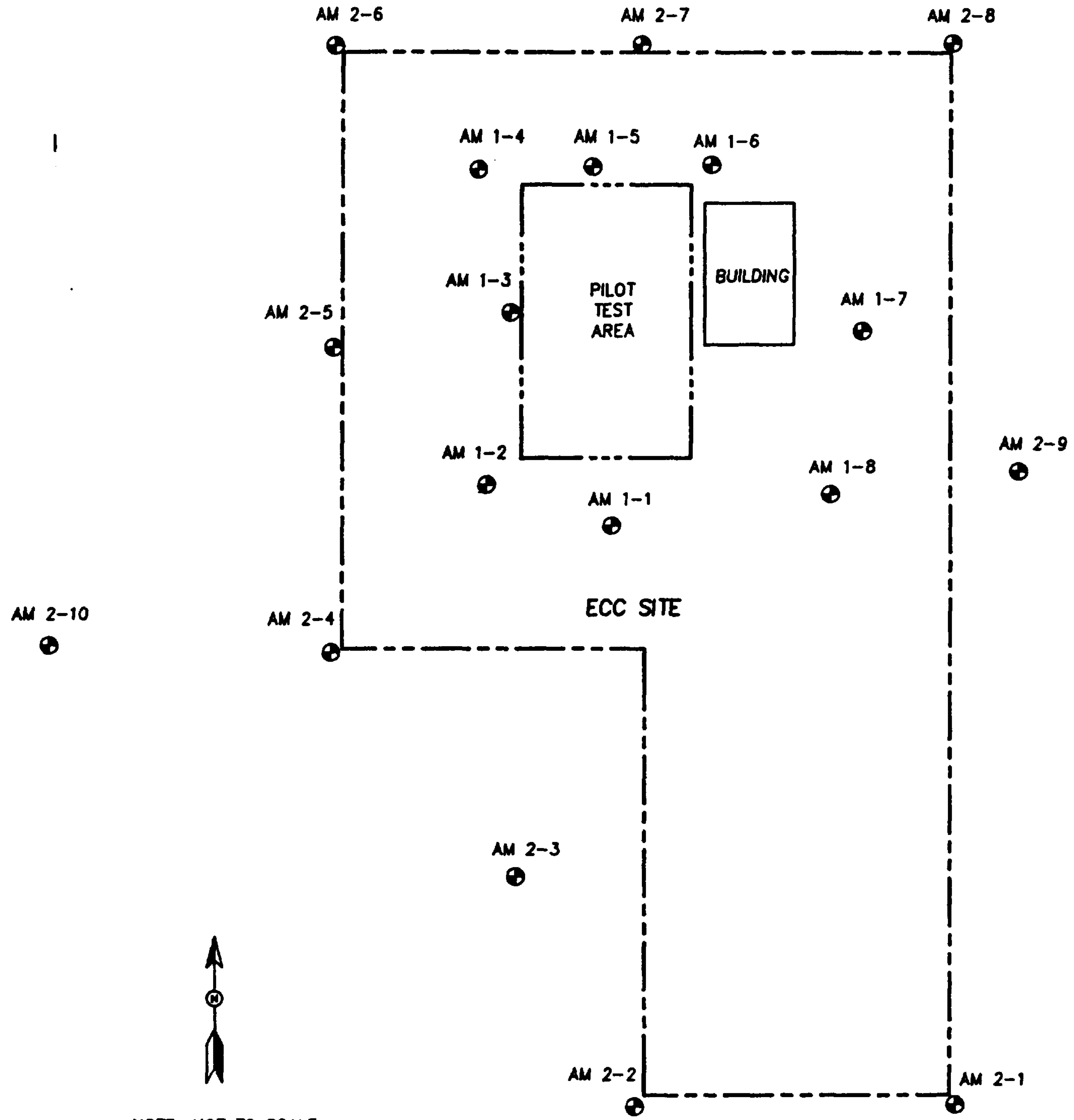
- improved prediction of the zone of influence
- enhanced prediction of the steady-state rate of vapor extraction and soil treatment
- improved design criteria and confidence level for size, duration and cost of operation.



ECC SITE
SOIL VAPOR EXTRACTION SYSTEM
PILOT TEST LAYOUT

ERM–North Central, Inc.

FIGURE 1–1



NOTE: NOT TO SCALE

ECC SITE
AIR MONITORING LOCATIONS

ERM-North Central, Inc.

FIGURE
1-2

APPENDIX A

TERRA VAC DATA

Date: 7/5/88

Deliver to: Paul Kopydlowski

Company: ERM

FAX #: 312-940-9280

From: Tony Dall

Company: TERRA VAC SAN FRANCISCO OFFICE
14204 Doolittle Drive
San Leandro, CA 94577
(415) 351-8900

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FAX Type: Group III

Total number of pages including this cover letter: 6

Description of Contents: Operations and sample data at ECC site up to + incl 6/27 (preliminary data)

Message: Note: Sample volume and flow changes must be considered ~~then~~ in conjunction with GC readout of concentrations.

* Approximately 300 lbs VOCs removed as of 6/27.

* Daily rates increase with initial development, then start to decline.

* Highest outer perimeter air rdg = 2.5 ppm with wind coming across NSL.
Highest inner perimeter air rdg = 1.5 ppm.

NO WATER

ECC SOILS DATA
TERRA VAC PILOT TEST

4 & VE-1 VM-1.2.3.4 & VE-1 VM-1.2.3.4 & VE-1

	===== SOIL CONCENTRATION (PPM) ========= SOIL CONCENTRATION (PPM) ===								
	DEPT FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE ppm	mp-XYL ppm	TOTAL ppm
M-1-3	3.0	.5	8.9	.0	.7	1.0	.0	.1	11.3
M-1-6	6.0	.3	11.8	.0	5.9	.2	.0	.0	18.2
M-2-3	3.0	2.2	26.2	.0	74.6	6.2	65.4	1.7	176.4
M-2-6	6.0	1.0	14.9	.0	2.3	.5	8.3	.1	27.0
M-3-3	3.0	.0	3.6	.0	.1	.7	.0	.0	4.4
M-3-5	5.0	.4	8.8	.0	10.8	.5	3.1	.0	23.7
M-4-3	3.0	1.6	1.7	.0	.8	.0	.9	.0	5.1
M-4-6	6.0	2.5	17.1	.0	10.7	1.2	2.0	.0	33.5
E-1-3	3.0	2.8	128.5	.0	80.5	5.9	1.5	1.8	220.9
E-1-6	6.0	12.5	90.2	.0	232.5	8.7	47.4	1.9	393.3
E-1-9	9.0	.0	.0	.0	.1	.0	.0	.0	.1

TERRA VAC/ ECC - E

			XX	VE-1					VE-1						
SAMPLE TIME			XX	((OPERATION DATA))					((GAS CHROMATOGRAPH READOUT))						
DATE	HRS	MIN	XX	SAMP NUM	INJ VOL (ul)	WELL VAC ("Hg)	FLOW RATE (SCFM)	FLOW RATE (ACFM)	1,1 DCE (mg/l)	1,1,1 TCA (mg/l)	TCE (mg/l)	TOL (mg/l)	PCE (mg/l)	M,P-XYL (mg/l)	TOTAL AREA 1000X
Jun-14	12	17	XX	888											0
Jun-14	12	18	XX	888	100	1.0									0
Jun-14	12	38	XX	888	100	1.0									0
Jun-14	13	18	XX	888	100	1.0									0
Jun-14	13	31	XX	888	100	1.0									0
Jun-14	14	31	XX	888	100	1.0									0
Jun-14	15	31	XX	888	100	1.0									0
Jun-14	15	40	XX	888	100	1.0									0
Jun-14	16	29	XX	888	100	1.0									0
Jun-14	17	29	XX	888	100	1.0									0
Jun-14	20	42	XX	888	100	1.0									0
Jun-15	8	39	XX	888	100	1.0									0
Jun-15	9	20	XX	888	100	1.0									0
Jun-15	11	30	XX	888	100	1.0									0
Jun-15	12	10	XX	777	100	8.8									0
Jun-15	12	23	XX	113	100	9.0	4	5	.606	1.501	2.584	.059	.267	.007	1045
Jun-15	12	27	XX	999	100	8.8	4	5							
Jun-15	14	50	XX	116	100	9.0	4	5	.078	.782	.558	.072	.082	.020	490
Jun-15	15	55	XX	999	100	9.0	8	10							
Jun-15	16	2	XX	999	100	9.0	8	10							
Jun-16	10	48	XX	999	100	8.5	13	15							
Jun-16	13	6	XX	121	100	8.0	13	15	.008	.065	.030	.016	.008	.003	61
Jun-16	15	45	XX	999	100	1.0	15	15							
Jun-16	16	30	XX	888	100	1.0	15	15							
Jun-16	19	15	XX	777	100	1.0	15	15							
Jun-17	10	45	XX	126	100	8.8	17	20	.016	.081	.082	.012	.015	.003	68
Jun-17	11	0	XX	888	100	1.0									
Jun-17	11	40	XX	777	100	1.0									
Jun-17	15	0	XX	128	500	10.0	4	5	.053	.339	.213	.070	.041	.017	280
Jun-18	10	0	XX	132	500	7.8	4	5	.049	.339	.215	.061	.044	.016	256
Jun-19	10	30	XX	135	500	7.1	4	5	.038	.424	.256	.055	.048	.017	296
Jun-19	10	47	XX	888	100	1.0									
Jun-19	11	40	XX	888	100	1.0									
Jun-20	9	20	XX	888	100,	1.0									
Jun-20	9	50	XX	888	100	1.0									
Jun-20	10	35	XX	888	100	1.0									
Jun-20	15	0	XX	888	100	1.0									
Jun-21	9	0	XX	888	100	1.0									
Jun-21	9	33	XX	888	100	1.0									
Jun-21	10	30	XX	777	100	1.0									
Jun-22	10	0	XX	140	500	14.6	4	5	.094	.588	.692	.047	.101	.017	364
Jun-22	16	10	XX	145	500	14.4	4	5	.081	.663	.690	.057	.124	.022	415
Jun-23	10	0	XX	146	500	14.5	4	5	.095	.899	.856	.071	.136	.032	556
Jun-24	11	0	XX	154	500	14.5	4	5	.019	.202	.211	.017	.033	.009	135
Jun-24	14	30	XX	888	500		5	5							
Jun-24	16	34	XX	999	500	10.0	4	5							
Jun-24	16	50	XX	999	500	8.7	4	5							
Jun-24	17	35	XX	999	500	8.9	4	5							
Jun-25	9	15	XX	999	500	8.0	4	5							
Jun-27	11	30	XX	160	500	6.8	4	5	.026	.437	.290	.069	.041	.036	277
Jun-27	16	0	XX	888	500	6.8	4	5							

Preliminary data

ECC SOILS DATA
TERRA VAC PILOT TEST

	HEW-1	HEW-1	HEW-1	HEW-1	HEW-1	HEW-1		HEW-1	HEW-1
	SOIL CONCENTRATION (PPM)								
	DEPTH FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE ppm	mp-XYL ppm	TOTAL ppm
1-3-3	3.0	.2	3.2	NA	7.7	1.9	4.5	1.9	19.4
1-6-7	7.0	.4	2.4	NA	4.5	2.1	9.6	2.2	9.4
6-9	9.0	.1	.0	NA	.0	.0	.1	.0	.2
12-4	4.0	2.4	59.6	NA	99.7	5.1	187.5	2.3	166.7
12-7	7.0	4.5	63.9	NA	125.0	5.9	155.2	2.2	199.3
20-2	2.0	6.8	18.3	NA	59.0	10.6	2.4	2.9	94.5
25-7	7.0	3.9	3.8	NA	24.5	4.0	11.5	1.7	41.1
35-5	5.0	7.7	45.6	NA	7.9	4.6	4.0	1.8	65.7
35-6	6.0	62.3	96.2	NA	49.7	9.4	103.1	3.8	217.6
40-3	3.0	6.3	4.3	NA	2.0	.5	1.6	.2	13.1
40-5	5.0	1.5	22.4	NA	2.6	1.0	1.1	.5	27.5
40-7	7.0	.7	67.4	NA	9.0	6.9	1.9	.6	84.1

	HEW-2		HEW-2	HEW-2	HEW-2	HEW-2	HEW-2	HEW-2	HEW-2
	SOIL CONCENTRATION (PPM)								
	DEPTH FT.	DCE ppm	TCA ppm	BZ ppm	TCE ppm	TOL ppm	PCE	mp-XYL	TOTAL ppm
2-5-3	3.0	.5	3.6	NA	6.5	3.3	1.5	2.3	14.0
5-7	7.0	1.1	180.8	NA	10.6	19.7	4.9	8.8	212.1
5-9	9.0	.2	5.1	NA	8.5	1.2	8.7	1.0	15.0
15-2	2.0	1.5	109.6	NA	6.8	15.3	2.1	3.4	133.2
15-8	8.0	1.1	83.0	NA	16.2	13.9	2.2	4.9	114.1
18-5	5.0	1.1	40.2	NA	12.0	.8	1.9	.1	54.2
22-3	3.0	.4	54.7	NA	20.1	4.0	4.7	1.8	79.1
22-8	8.0	.1	1.8	NA	.7	.4	.2	.2	3.0
35-3	3.0	1.6	37.9	NA	58.7	18.1	26.4	10.1	116.2
35-4	4.0	.6	54.5	NA	333.9	25.5	35.0	6.4	414.4
35-7	7.0	1.4	68.9	NA	71.3	19.2	20.6	13.7	160.7
43-5	5.0	2.5	153.5	NA	24.8	13.3	5.6	5.8	194.1
45-2	2.0	.9	68.9	NA	21.7	12.5	3.5	4.1	103.9
45-6	6.0	1.6	116.3	NA	15.4	14.1	2.5	4.6	147.8

T2-5-3 = HEW-2 sample, 5 ft from end of trench at 3 ft depth

TERRA VAC/ ECC - ERM

				HEW-1					HEW-1							
SAMPLE TIME			XX	((OPERATION DATA))					((GAS CHROMATOGRAPH READOUT))							
			XX		INJ	WELL	FLOW	FLOW	1,1	1,1,1				M,P-	TOTAL	
			XX	SAMP	VOL	VAC	RATE	RATE	DCE	TCA	TCE	TOL	PCE	XYL	AREA	
DATE	HRS	MIN	XX	NUM	(ul)	("Hg)	(SCFM)	(ACFM)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	1000X	
Jun-14	12	17	XX	888												
Jun-14	12	18	XX	888	100	1.0										
Jun-14	12	38	XX	888	100	1.0										
Jun-14	13	18	XX	888	100	1.0										
Jun-14	13	31	XX	888	100	1.0										
Jun-14	14	31	XX	888	100	1.0										
Jun-14	15	31	XX	888	100	1.0										
Jun-14	15	40	XX	888	100	1.0										
Jun-14	16	29	XX	888	100	1.0										
Jun-14	17	29	XX	888	100	1.0										
Jun-14	20	42	XX	888	100	1.0										
Jun-15	8	39	XX	888	100	1.0										
Jun-15	9	20	XX	888	100	1.0										
Jun-15	11	30	XX	888	100	1.0										
Jun-15	12	10	XX	888	100	1.0										
Jun-15	12	23	XX	777	100	1.0										
Jun-15	12	27	XX	114	100	8.5	2	2	.377	1.380	.701	.034	1.015	.008	1210	
Jun-15	14	50	XX	115	100	9.5	17	20	.040	.241	.107	.030	.170	.015	194	
Jun-15	15	55	XX	999	100	9.5	17	20								
Jun-15	16	2	XX	999	100	9.5	25	30								
Jun-16	10	48	XX	999	100	9.5	33	40								
Jun-16	13	6	XX	122	100	8.8	34	40	.012	.065	.027	.006	.049	.003	44	
Jun-16	15	45	XX	999	100	8.8	34	40								
Jun-16	16	30	XX	888	100	1.0	39	40								
Jun-16	19	15	XX	777	100	1.0	52	53								
Jun-17	10	45	XX	124	100	8.4	68	80	.009	.054	.022	.003	.036	.001	54	
Jun-17	11	0	XX	888	100	1.0										
Jun-17	11	40	XX	777	100	1.0										
Jun-17	15	0	XX	127	500	9.7	82	100	.031	.227	.090	.018	.163	.007	158	
Jun-18	10	0	XX	131	500	7.2	90	103	.022	.192	.085	.013	.130	.005	102	
Jun-19	10	30	XX	134	500	6.8	114	130	.014	.187	.090	.012	.147	.004	152	
Jun-19	10	47	XX	888	100	1.0										
Jun-19	11	40	XX	888	100	1.0										
Jun-20	9	20	XX	888	100	1.0										
Jun-20	9	50	XX	888	100	1.0										
Jun-20	10	35	XX	777	100	1.0										
Jun-20	15	0	XX	138	500	9.5	141	170	.013	.161	.074	.011	.133	.004	78	
Jun-21	9	0	XX	139	1000	7.8	185	215	.020	.291	.138	.023	.255	.009	179	
Jun-21	9	33	XX	888	100	1.0										
Jun-21	10	30	XX	888	100	1.0										
Jun-22	10	0	XX	888	100	1.0										
Jun-22	16	10	XX	888	100	1.0										
Jun-23	10	0	XX	888	100	1.0										
Jun-24	11	0	XX	888	100	1.0										
Jun-24	14	30	XX	888	100	1.0										
Jun-24	16	34	XX	888	100	1.0										
Jun-24	16	50	XX	888	100	1.0										
Jun-24	17	35	XX	888	100	1.0										
Jun-25	9	15	XX	888	100	1.0										
Jun-27	11	30	XX	888	100	1.0										
Jun-27	16	0	XX	888	100	1.0										

Preliminary data

TERRA VAC/ ECC - E

			XX	HEW-2					!!	HEW-2							!!
SAMPLE TIME			XX	<< OPERATION DATA >>					!!	<< GAS CHROMATOGRAPH READOUT >>							!!
			XX		INJ	WELL	FLOW	FLOW	!!	1,1	1,1,1				M,P-	TOTAL	!!
			XX	SAMP	VOL	VAC	RATE	RATE	!!	DCE	TCA	TCE	TOL	PCE	XYL	AREA	!!
DATE	HRS	MIN	XX	NUM	(ul)	("Hg)	(SCFM)	(ACFM)	!!	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	1000X	!!
Jun-14	12	17	XX	777					!!							0	!!
Jun-14	12	18	XX	106	100	10.0	4	5	!!	.163	1.170	1.150	.094	.200	.019	1020	!!
Jun-14	12	38	XX	107	100	10.0	4	5	!!	.146	1.890	.863	.121	.109	.024	1105	!!
Jun-14	13	18	XX	108	100	10.0	4	5	!!	.162	1.870	.791	.129	.132	.031	930	!!
Jun-14	13	31	XX	888	100	10.0	4	5	!!								!!
Jun-14	14	31	XX	777	100	10.0	4	5	!!								!!
Jun-14	15	31	XX	109	100	7.5	4	5	!!	.128	2.216	.903	.171	.131	.048	990	!!
Jun-14	15	40	XX	888	100	8.0	4	5	!!								!!
Jun-14	16	29	XX	777	100	9.0	4	5	!!								!!
Jun-14	17	29	XX	110	100	8.5	8	10	!!	.103	1.953	.915	.182	.138	.057	926	!!
Jun-14	20	42	XX	111	100	9.0	8	10	!!	.077	1.328	.823	.152	.130	.051	728	!!
Jun-15	8	39	XX	888	100	9.3	17	20	!!								!!
Jun-15	9	20	XX	777	100	9.0	17	20	!!								!!
Jun-15	11	30	XX	112	100	9.0	17	20	!!	.046	.724	.626	.104	.104	.036	475	!!
Jun-15	12	10	XX	999	100	10.0	16	20	!!								!!
Jun-15	12	23	XX	999	100	10.0	16	20	!!								!!
Jun-15	12	27	XX	999	100	9.0	17	20	!!								!!
Jun-15	14	50	XX	999	100	8.5	17	20	!!								!!
Jun-15	15	55	XX	117	100	9.5	17	20	!!	.036	.520	.491	.077	.084	.025	358	!!
Jun-15	16	2	XX	999	100	8.5	25	30	!!								!!
Jun-16	10	48	XX	999	100	9.0	33	40	!!								!!
Jun-16	13	6	XX	120	100	9.1	38	45	!!	.020	.266	.283	.042	.051	.012	191	!!
Jun-16	15	45	XX	999	100	9.0	38	45	!!								!!
Jun-16	16	30	XX	888	100	1.0	44	45	!!								!!
Jun-16	19	15	XX	777	100	12.0	54	70	!!								!!
Jun-17	10	45	XX	125	100	7.8	106	123	!!	.014	.134	.162	.021	.034	.007	143	!!
Jun-17	11	0	XX	888	100	1.0	0		!!								!!
Jun-17	11	40	XX	777	100	1.0	0		!!								!!
Jun-17	15	0	XX	129	100	9.0	115	138	!!	ND	.060	.081	.011	.018	.003	50	!!
Jun-18	10	0	XX	133	500	6.3	146	164	!!	.021	.232	.354	.054	.079	.019	223	!!
Jun-19	10	30	XX	136	500	5.8	202	225	!!	.012	.164	.271	.039	.050	.015	195	!!
Jun-19	10	47	XX	888	100	1.0	0		!!								!!
Jun-19	11	40	XX	777	100	1.0	0		!!								!!
Jun-20	9	20	XX	137	500	7.0	210	240	!!	nd	.115	.214	.032	.040	.012	188	!!
Jun-20	9	50	XX	888	100	1.0	0		!!								!!
Jun-20	10	35	XX	888	100	1.0	0		!!								!!
Jun-20	15	0	XX	888	100	1.0	0		!!								!!
Jun-21	9	0	XX	888	100	1.0	0		!!								!!
Jun-21	9	33	XX	888	100	1.0	0		!!								!!
Jun-21	10	30	XX	888	100	1.0	0		!!								!!
Jun-22	10	0	XX	888	100	1.0	0		!!								!!
Jun-22	16	10	XX	888	100	1.0	0		!!								!!
Jun-23	10	0	XX	888	100	1.0	0		!!								!!
Jun-24	11	0	XX	888	100	1.0	0		!!								!!
Jun-24	14	30	XX	888	100	1.0	0		!!								!!
Jun-24	16	34	XX	777	100	1.0	0		!!								!!
Jun-24	16	50	XX	155	500	7.2	205	235	!!	.027	.551	.391	.067	.087	.028	377	!!
Jun-24	17	35	XX	156	500	7.2	205	235	!!	.020	.362	.333	.055	.072	.023	259	!!
Jun-25	9	15	XX	157	500	5.9	233	260	!!	.011	.135	.209	.030	.037	.012	184	!!
Jun-27	11	30	XX	159	500	4.3	315	340	!!	.006	.051	.118	.023	.020	.007	78	!!
Jun-27	16	0	XX	160	1000	4.2	315	340	!!	.012	.101	.244	.048	.040	.016	197	!!

Preliminary data

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TABLE 1

VAPOR EXTRACTION FEASIBILITY ANALYSIS TABLE

Rating	Parameter: Contaminant Henry's Law Constant (atm-m^3/mol) (wf=3)	Soil Permeability ($cm^3/cm^2/sec$) (wf=2)	Ground Water Interference (wf=1)
Good (Score 80)	$K_h > 10^{-4}$	Sands $K>10^{-3}$	90% of total contaminant mass in unsaturated zone
Fair (Score 60)	$10^{-7}< K_h <10^{-4}$	Mixed soils $10^{-6}<K<10^{-3}$	>10% in saturated zone, feasible dewatering
Poor (Score 30)	K_h<10-7	Clays $K<10^{-6}$	>10% in saturated zone, difficult dewatering

wf = Weighting Factor

Equation 1. Score = $S_T = \sum S_i W_j / \sum W_j$

where: S_T = total score

S_i = score for parameter i

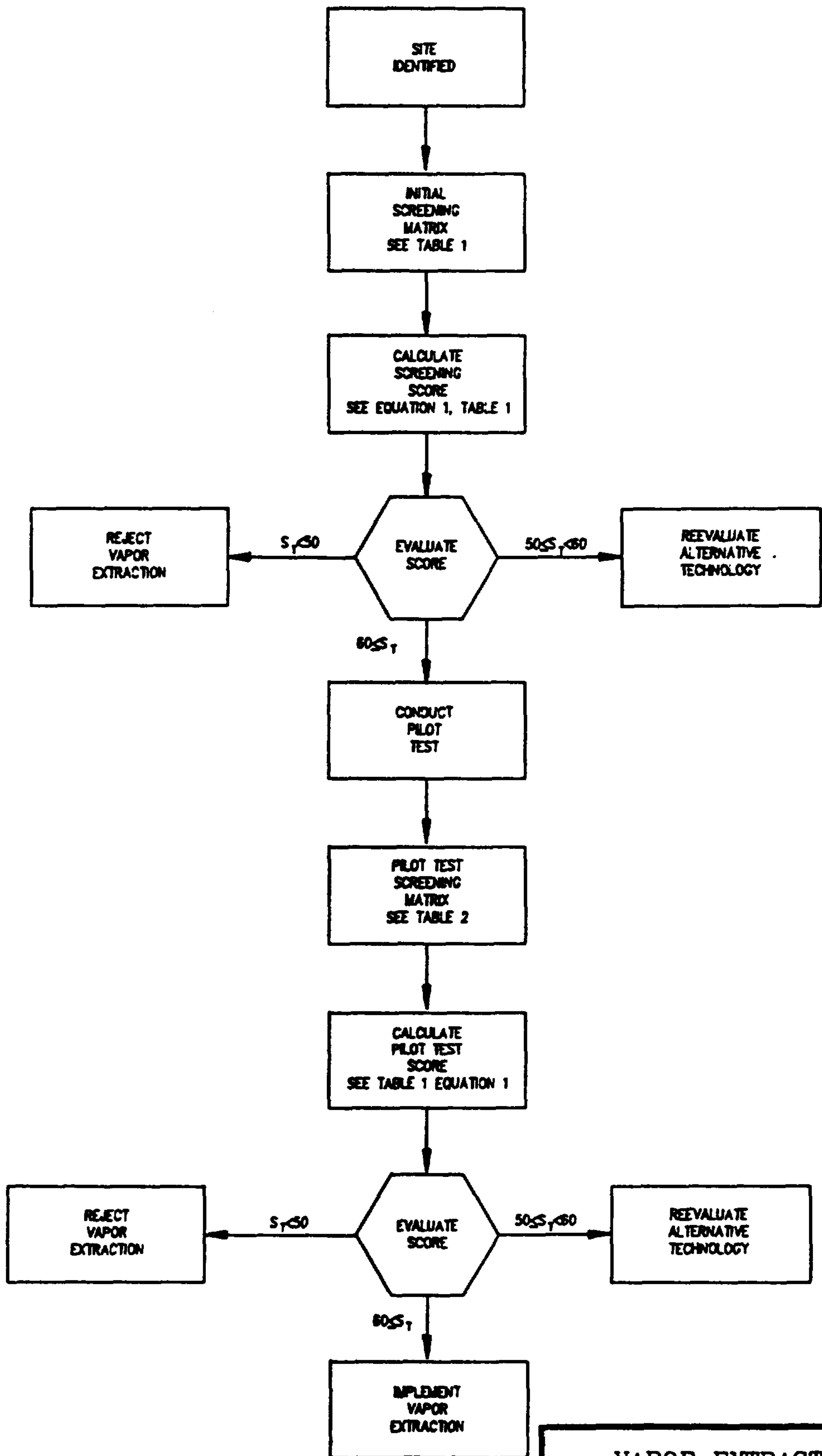
W_j = weighting factor for parameter

TABLE 2

VAPOR EXTRACTION PERFORMANCE ANALYSIS TABLE

Rating	Zone of Influence (wf=3)		Initial Contaminant Mass Extraction Rate (wf=2)	Emmission Controls Required (wf=1)
	Sands	Clays		
Good (Score 80)	>50 ft.	>20 ft.	>5% total mass on site/day	None
Fair (Score 60)	20<ZOI<50	10<ZOI<20	1%/day<ER<5%/day	During Initial Remediation
Poor (Score 30)	<25 ft.	<10 ft.	<1%/day	Continuously During Remediation

wf = Weighting Factor
ZOI = Zone of Influence
ER = Extraction Rate



VAPOR EXTRACTION EVALUATION

ERM-North Central, Inc.

FIGURE 1

APPENDIX B

SITE SPECIFIC EVALUATION OF VAPOR EXTRACTION

SITE SPECIFIC EVALUATION OF
VAPOR EXTRACTION APPLICATION

INTRODUCTION

Vapor extraction is a process used to remove volatile pollutants from contaminated soils (1,2,3,4). The process works by withdrawing volatile contaminants from soil, in situ. A subsurface vacuum is propagated from extraction wells which causes vapors to migrate to the extraction wells. The vapors are brought from the wells to the surface where they are collected and treated.

The effectiveness of the vapor extraction process is influenced by the contaminant volatility, the soil stratigraphy and the location of the ground water table. The implementation of vapor extraction therefore requires site specific evaluation. This report describes a procedure to evaluate the application of vapor extraction technology for a particular site.

SUMMARY OF METHODOLOGY

A site investigation must be performed to determine the type, extent and severity of contamination. A CERCLA remedial investigation is generally sufficient for this purpose. Certain data collected from the site are scored and weighted to determine the feasibility of vapor extraction for the given site. Based on the calculated feasibility score, a decision is made either to reject vapor extraction for the site, to reevaluate alternative technologies, or to conduct a vapor extraction pilot test.

If site conditions (as defined by the feasibility score) are favorable, pilot tests are performed. Performance data from the pilot test are then evaluated through a scoring and weighting procedure analogous to the feasibility scoring procedure. A decision is made either to reject the vapor extraction process as unsuitable for the site conditions, to reevaluate alternative technologies, or to affirm that the vapor extraction process can be applied to the site. The methodology is graphically depicted in Figure 1.

SITE SPECIFIC DATA REQUIREMENTS

Site remedial investigation activities provide the data needed to support decisions made in feasibility studies. Vapor extraction is dependent upon the ability of contaminants to volatilize and move through the soils to a collection system. A site characterization study must therefore define the types and extent of contamination on a site and the soil matrix in which the contaminants are found. Specifically, the site investigation must define the contaminants, their distribution and the soil classification on a site.

The site characterization study must also define the percent of total contamination in the unsaturated zone. If a significant portion of the total contaminant mass is contained in the saturated zone, the feasibility of dewatering must also be defined. Superfund site remedial investigation/feasibility studies typically provide the site characteristic data described above.

FEASIBILITY ANALYSIS

Assuming that the required data are available, a feasibility analysis is performed to determine if the vapor extraction process should be considered for a site. Initially the most important concern is the volatility of the contaminants (2,5). The volatility of the compounds will determine their transport from the liquid phase as attached to soil particles to the vapor phase in the soil gas.

Volatility

For evaluation purposes, volatility is indicated by Henry's Law constants. The use of adsorption isotherms to account for the soil/liquid interaction is desirable but adsorption coefficients are generally unavilable for most compounds and soil types (6). Contaminants with Henry's Law constants greater than 10^{-4} (atm-m^3/mol) are considered amenable to removal by vapor extraction. Compounds with Henry's Law constants less than 10^{-7} should be considered essentially nonvolatile (7) and are poor candidates for evaporative technologies. Compounds with Henry's Law constants in the range of 10^{-4} to 10^{-7} are considered fair candidates for vapor extraction.

Stratigraphy

The second factor of concern is the transport of vapor from the soil to the collection system. This transport is dependent on the vacuum developed on the site (which is a process operation parameter) and the characteristics of the soil. The movement of gasses in porous media is described by Darcy's Law (6). The coefficient of permeability used in Darcy's law t[illegible] describe the transport of ground water through soil ma[illegible] used to characterize the flow of other fluids through soil such as air or vapor. Soil permeability may be estimated based on a classification of the representative materials in the soil. Sandy soils which generally have a coefficient of permeability greater than 10^{-3} (cm^3/cm^2/sec)(8) are good candidates for the use of the vapor extraction process. Mixed soils with coefficients of permeability between 10^{-3} and 10^{-6} are considered fair candidates for the application of this technology. Soils with coefficients of permeability less than 10^{-6} are considered poor candidates for the application of this technology.

Ground Water

The presence of ground water will inhibit the transport of volatile pollutants from the saturated soil matrix to the soil gas above. If 90% of the total mass of pollutants are in the unsaturated zone of the soil, this site is considered a good candidate for the application of vapor extraction. If a significant mass of pollutants is in the saturated zone, dewatering may be used to remove the ground water and enhance the transport of pollutants from the soil matrix. The practicality of dewatering a site is dependent on the depth, soil material, dewatering area, ground water recharge, and discharge requirements for the ground water. Hydrogeologi and ground water quality data must be available to evaluate t e ability to dewater a site. If greater than 10% of the total mass of pollutants on-site is in the saturated zone and dewatering is feasible, a site is considered to be a fair candidate for vapor extraction. If greater than 10% of the total mass of pollutants is below the saturated zone and the site is difficult to dewater, then the site is considered to be a poor candidate for vapor extraction.

Initial Screening Score

The overall evaluation of a site uses the weights and parametric scores as shown in Table 1. The primary parameter is the volatility of the contaminants which is given a weighting factor of 3. The transport characteristics of the contaminants in the soil are of secondary importance and are weighted with a factor of 2. Finally, the potential for ground water interference is weighted with a factor of 1. The values of the parameters are scored as good (80 points), fair (60 points), or poor (30 points) as shown in Table 1.

An overall score is then calculated according to Equation 1 on Table 1. This score is used to evaluate the feasibility of using vapor extraction technology on a particular site. A score of 60 or more generally indicates that use of the technology is feasible and that a pilot test should be conducted. A score less than 60 but greater than or equal to 50 is marginal and indicates a need to reevaluate alternate technologies. A score of less than 50 indicates that vapor extraction technology is not appropriate for the site and should not be selected for use as a remediation technology.

PERFORMANCE ANALYSIS

It is necessary to perform a pilot test to determine how the process will perform for a particular application. The pilot test is used to determine the zone of influence of the vapor extraction well, the initial pollutant mass extraction rate, and the necessity for emission controls. These parameters, in addition to the site stratigraphy and contaminant distribution, are critical to determining the cost of a vapor extraction system.

Zone of Influence

The radial zone of influence of a well will determine the number of extraction wells required. The zone of influence is a function of the air extraction rate and the extraction well negative pressure. As the zone of influence increases, the number of extraction wells required decrease.

Initial Extraction Rate

The initial extraction rate will determine the length of time an extraction system must be operated. The contaminant mass extraction rate may be determined by multiplying the air extraction rate by the extracted air contaminant concentration. Since the contaminant distribution is known from the site investigation, the extraction rate may be expressed as a percent of the total contaminant mass. The initial extraction rates can be used to estimate the total operating time for site remediation.

Emission Controls

Emission controls may be used to reduce the concentration of the extracted air contaminants. Emmission controls may be applied during the early stages of a vapor extraction remediation project, when the mass extraction rate is likely to be high. Emmission controls will increase the cost of a system.

Pilot Test Screening Score

These three factors are as shown in Table 2. A performance analysis score is then calculated using Equation 1 (Table 1). If the score is less than 50 points, the vapor extraction technology is rejected as impractical. If the score be greater than or equal to 50 but less than 60, the alternative technologies should be reevaluated. If the score is greater than 60 the process is recommended for the site.

Verification of Clean Up

Final soil contaminant concentrations may be calculated using mass balance techniques based on the difference between the initial contaminant mass on site and the field determined mass extraction rate. Soil samples may be collected to confirm calculated results. Alternatively, laboratory soil aeration studies may be conducted on field collected samples to determine an effective Henry's Law factor. This factor would incorporate soil adsorption effects and other interferences expected under field conditions. This factor, the gas flow rate and soil characteristics may be used to estimate the aeration time required to meet final contaminant concentration clean up standards (6). However, laboratory studies may require from 4 weeks to 6 months (5) and will not eliminate the need for pilot testing.

ERM-North Central, Inc.

MEMORANDUM

TO: Jerry Amber, Ford Motor Company
Don Smith, Pratt & Lambert

FROM: Roy O. Ball, ERM-North Central, Inc. ROB/PJA

DATE: July 13, 1988

SUBJECT: Interim Report of Vapor Extraction Pilot Test

Enclosed please find a copy of the photograph which should be included in the report referenced above.

cc: Timothy Harker
The Harker Firm

John Buck
Indiana Department of Environmental Management

Karen Vendl
U.S. EPA

Mike Disabato
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